Phys 131
Fall 2015

Fundamental Mechanics: Class Exam III

4 November 2015

Name: _____ **Total:** /70

Instructions

- There are 8 questions on 5 pages.
- Show your reasoning and calculations and always justify your answers.

Physical constants and useful formulae

$g = 9.80\,\mathrm{m/s^2}$

Question 1

Two ice skaters, Alice with mass 60 kg and Bob with mass 90 kg, slide toward each other on a sheet of ice. Alice moves right with speed 10 m/s and Bob moves left with speed 5.0 m/s. They collide and hold each other, subsequently moving together. Determine their velocity (including direction) after the collision.

$m_A = 60\ \mathrm{kg}$
$v_A = 10\ \mathrm{m/s}$
$m_B = 90\ \mathrm{kg}$
$v_B = -5.0\ \mathrm{m/s}$
$m_C = 150\ \mathrm{kg}$

$P_f = P_i$

$m_C v_f = m_A v_A + m_B v_B$

$(150\,\mathrm{kg})v_f = 60\,\mathrm{kg}(10\,\mathrm{m/s}) + 190\,\mathrm{kg})(-5\,\mathrm{m/s})$

$(150\,\mathrm{kg})\,v_f = 600\ \mathrm{kg\cdot m/s} - 450\ \mathrm{kg\cdot m/s}$

$150\,\mathrm{kg}\,v_f = 150\ \mathrm{kg\cdot m/s}$

$v_f = 1\ \mathrm{m/s}$

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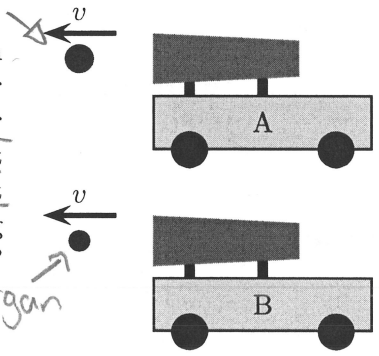
Kerrick

Question 2

Two identical carts are equipped with devices which can launch balls horizontally. Each is initially at rest and later launches a ball to the right; the speeds of the balls after launch are the same. However, the ball launched by cart A has a much greater mass than the ball launched by cart B. Which of the following is true (choose one) regarding the speeds of the carts after the balls have been launched? Ignore friction and air resistance.



Morgan

i) Both carts have speed 0 m/s.
ii) The speeds of the carts are the same but are not zero.
iii) Cart A has a larger speed.
iv) Cart B has a larger speed.

$P_f = P_i$

$m_A v_A + m_C v_C = 0 \quad m_A v_A = m_C v_C$

$\frac{m_B v_B}{m_C} = v_C \quad \frac{2 m_A v_A}{m_C} = v_C$

Bigger outcome

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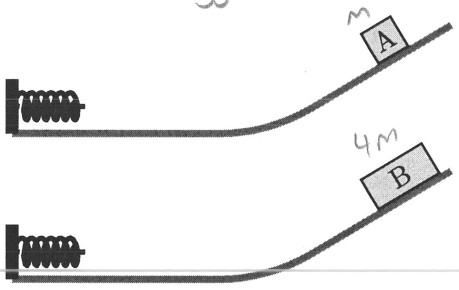
Question 3

Two boxes are released from rest at the same height on identical frictionless surfaces. The mass of box B is four times that of box A. They collide with and compress identical springs. Which of the following (choose one) is true regarding the maximum compression of each spring (Δs_A for that with box A, Δs_B for that with box B)?



i) $\Delta s_B = 4\Delta s_A$.
ii) $\Delta s_B = 2\Delta s_A$.
iii) $\Delta s_B = \Delta s_A$.
iv) $\Delta s_B = \frac{1}{2}\Delta s_A$.
v) $\Delta s_B = \frac{1}{4}\Delta s_A$.

$E_i = E_f$

$K_i + U_{Gi} + U_{Si} = K_f + U_{Gf} + U_{Sf}$

$mgy_i = \frac{1}{2} k (\Delta s)^2$

$2(mgy_i) = k(\Delta s)^2$

$\frac{2(mgy_i)}{k} = \Delta s^2$

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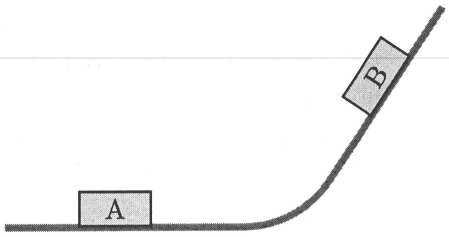
$\frac{8}{2} = 4 \qquad \frac{8mgy_i}{k} = \Delta s^2 = \text{Box B}$

$\frac{2mgy_i}{k} = \Delta s^2 = \text{Box A}$

Question 4

Two identical 4.0 kg blocks are initially at rest on a frictionless track as illustrated. Block B is 1.5 m above the horizontal surface. Block B is released and collides with block A. They stick together. Determine the speed of the two blocks after the collision.



$P_f = P_i$

$m_c v_f = m_A v_A + m_B v_B$ ($v_A = 0$)

$m_c v_f = m_B v_B$

$8.0\,kg(v_f) = (4.0\,kg)(5.4\,m/s)$

$8.0\,kg(v_f) = 21.6\,kg \cdot m/s$

$v_f = 2.7\,m/s$

$E_i = E_f$

$K_i + U_{Gi} = K_f + U_{Gf}$ ($K_i = 0$, $U_{Gf} = 0$)

$mgy_i = \frac{1}{2}mv_f^2$

$2mgy_i = mv_f^2$

$2gy_i = v_f^2$

$\sqrt{2gy_i} = v_f$

$\sqrt{2(9.8\,m/s)(1.5\,m)} = v_f$

$v_B = 5.4\,m/s$

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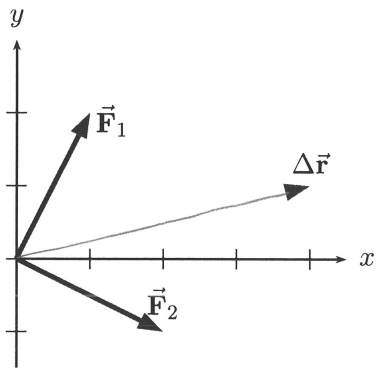
Question 5

A particle moves along the straight line illustrated by $\Delta\vec{r}$. During this time, two constant forces $\vec{F}_1$ and $\vec{F}_2$, illustrated to scale, act on the particle. Let W_1 be the work done by $\vec{F}_1$ and W_2 that done by $\vec{F}_2$. Which of the following (choose one) is true?

i) $W_1 = W_2 = 0$
ii) $W_1 = W_2 \neq 0$
iii) $W_1 > W_2$
iv) $W_1 < W_2$

$\vec{F}_1 \langle 1,2\rangle \cdot \langle 4,1\rangle$
$4+2=6$
$\vec{F}_2 \langle 2,-1\rangle \cdot \langle 4,1\rangle$
$8-1=7$



$W_2 > W_1$

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Question 6

A particle can move horizontally along the x axis. The potential energy of the particle is $U = (-10x + 5x^2)$ J. Determine the x-component of the force acting on the particle when it is at $x = 2$.

$-\frac{du}{dx} = -(-10 + 10x)$
$= 10 - 10x$
$-\frac{du}{dx}(2) = 10 - 10(2)$
$= 10 - 20$
$-\frac{du}{dx} = -10$

-10J

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Question 7

An crate is suspended by a rope and is lowered. While this happens, which of the following (choose one) is true of the work done by the rope W?

i) $W > 0$ if the crate speeds up and $W < 0$ if it slows down.
ii) $W < 0$ if the crate speeds up and $W > 0$ if it slows down.
iii) $W > 0$ regardless of the speed.
iv) $W < 0$ regardless of the speed.

$W = \vec{F} \cdot \Delta r \cdot \cos\theta$
$\theta = 180$
$W < 0$

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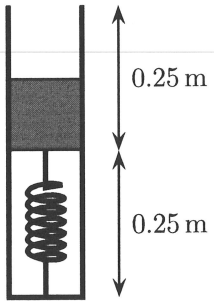
Question 8

A 2.0 kg block can move along a vertical cylinder. The block is held at rest against a spring with spring constant 400 N/m compressing it by 0.25 m. At this instant the base of the block is 0.25 m beneath the top of the cylinder. The block is released and when the base reaches the top of the cylinder, it leaves the spring, moving with speed 2.0 m/s. While it moves up the cylinder a constant kinetic friction force acts on the block.



a) Taking $y = 0$ at the base of the cylinder, determine the energy of the system at the moment that the block is released.

b) Determine the energy of the system at the moment when the base of the block reaches the top of the cylinder.

c) Determine the magnitude of the friction force.

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